Anticipating climate-change induced biome shifts for military installations

Dr. Jim Westervelt

Construction Engineering Research Lab Engineer
Research and Development Center

Army Corps

Dr. William Hargrove

Eastern Forest Environmental Threat Assessment Center

Forest Service

May, 2011

US Army Corps of Engineers
BUILDING STRONG®

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
MAY 2011		**00-00-2011 to 00-00-2011**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Anticipating climate-change induced biome shifts for military installations	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Army Engineer Research and Development Center,Construction Engineering Research Laboratory,PO Box 9005,Champaign,IL,61826-9005**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
Presented at the NDIA Environment, Energy Security & Sustainability (E2S2) Symposium & Exhibition held 9-12 May 2011 in New Orleans, LA.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**32**	

Overall Challenge

- Military installation ecosystems support:
  - Military training and testing
  - Populations of important plant/animal species
  - Examples of relatively pristine habitat

- Potential consequence of ecosystem shifts:
  - Training/testing type, time, capacity
  - Loss/gain of habitat
  - Changes to installation natural resource management plans

Question

Ideal:

How and when will ecosystems shift in response to climate change?

Two parts:

- ✔ Where can I currently find ecosystem driver conditions that match forecasted driver conditions?
- How and when will current ecosystems shift in response?

Ecosystem drivers

1. Precipitation during the locally hottest quarter
2. Precipitation during the locally coldest quarter
3. Precipitation during the locally driest quarter
4. Precipitation during the locally wettest quarter
5. Ratio of precipitation to potential evapotranspiration
6. Temperature during the coldest locally quarter
7. Temperature during the hottest locally quarter
8. Sum of monthly Temp avg where Temp avg >= 5 deg C
9. Integer number of consecutive months where Temp avg >= 5 deg C

CC-Based

Developed by Chris Zganjar at TNC using WORLDCLIM (http://www.worldclim.org)

10. Available water holding capacity of soil
11. Bulk density of soil
12. Carbon content of soil
13. Nitrogen content of soil
14. Compound topographic index (relative wetness)
15. Solar interception
16. Day/night diurnal temperature difference

Constant

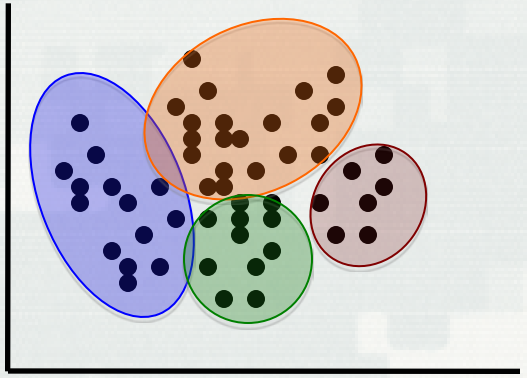
Develop global maps of drivers

- Choose general circulation models (GCM)
  - ► Hadley and PCM (high and low)
- Choose climate scenarios
  - ► A1 (higher CO_2) and B1(lower CO_2)
    - Explained on next slide
- Choose time
  - ► Current, 2055, 2085 (based on 30-yr averages)
- Collect maps (for current and 8 futures)

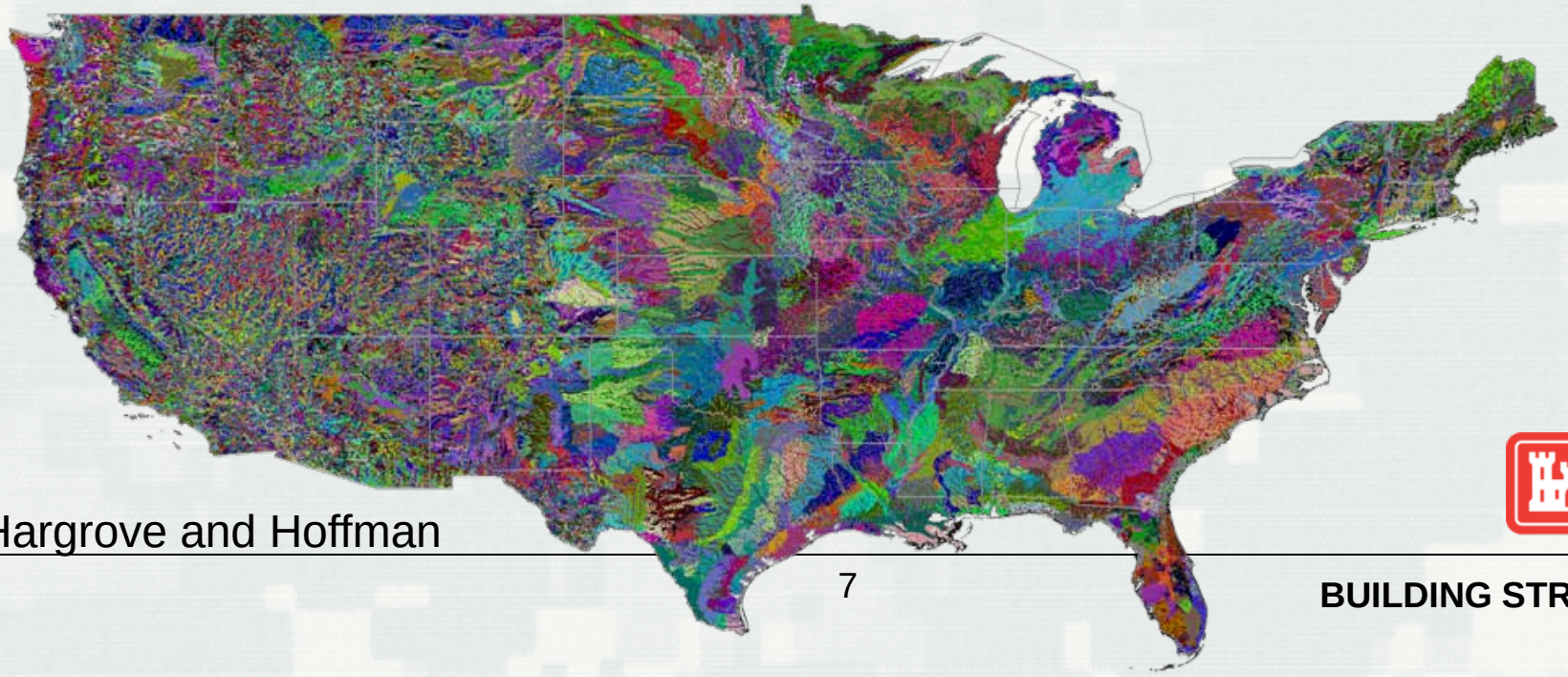
Scenarios

- A1 scenarios characterized by:
  - Rapid economic growth.
  - A global population that reaches 9 billion in 2050 and then gradually declines.
  - The quick spread of new and efficient technologies.
  - A convergent world.
- B1 scenarios are characterized by:
  - Rapid economic growth as in A1
  - Rapid changes towards a service and information economy.
  - Population as in A1.
  - Reductions in material intensity and the introduction of clean and resource efficient technologies.
  - An emphasis on global solutions to economic, social and environmental stability.

Cluster Analysis



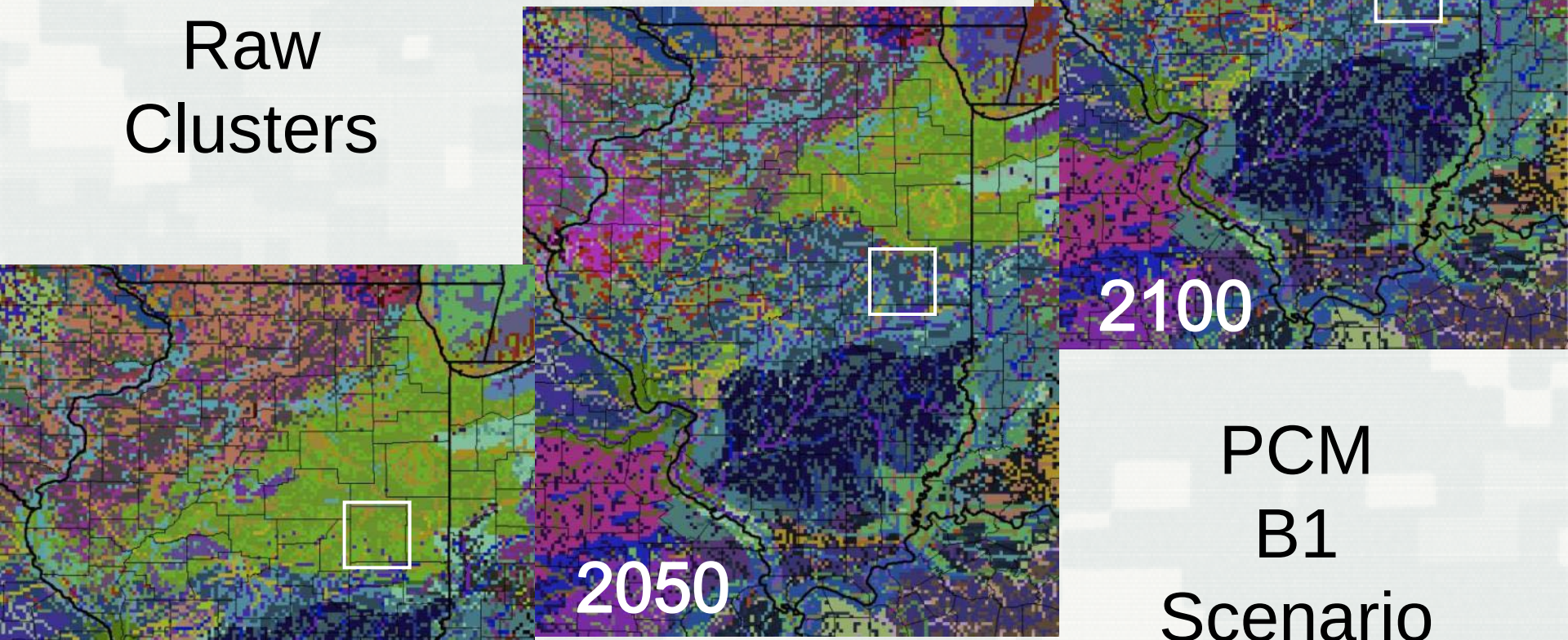
- Convert all maps to a standard-deviation form
- Run cluster analysis (30,000 clusters) Simultaneously grouping all 9 sets across the



Hargrove and Hoffman

Illinois

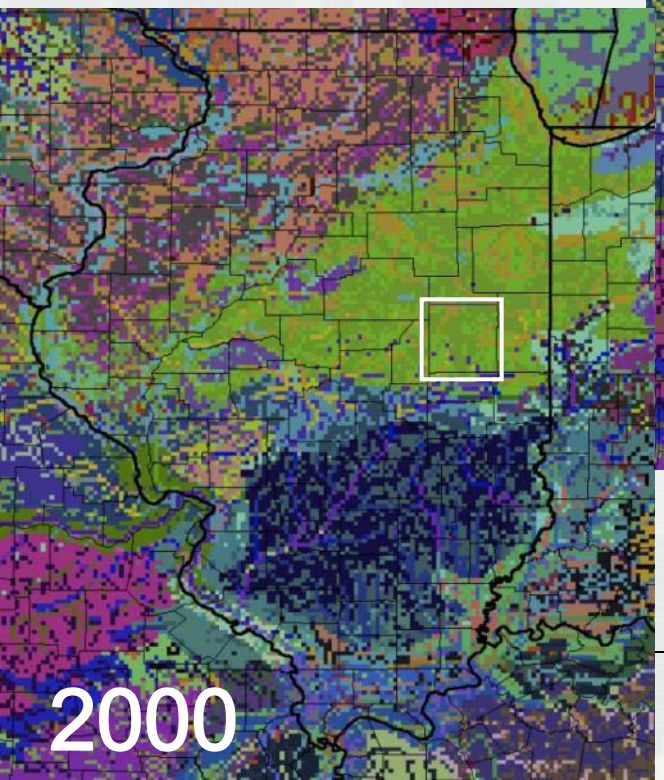
Raw Clusters

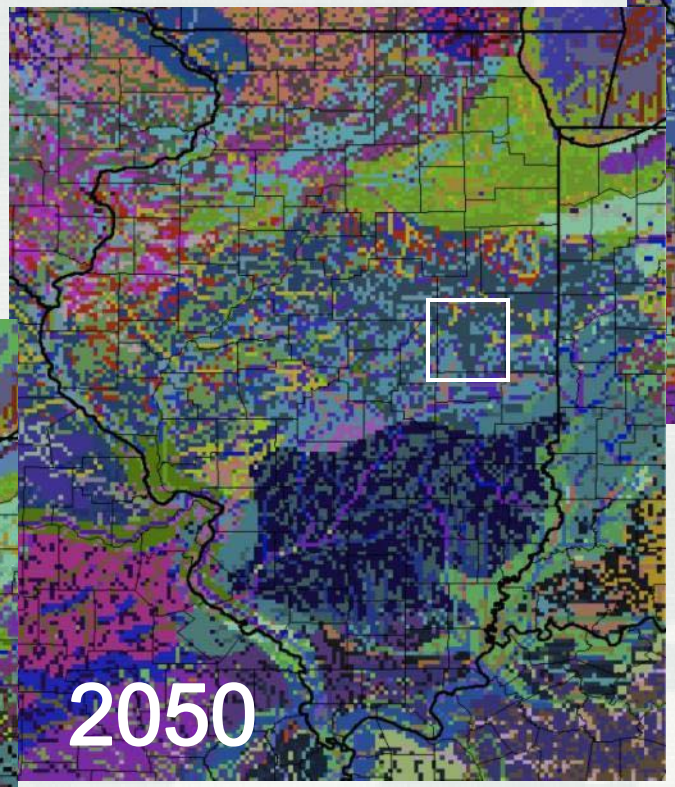


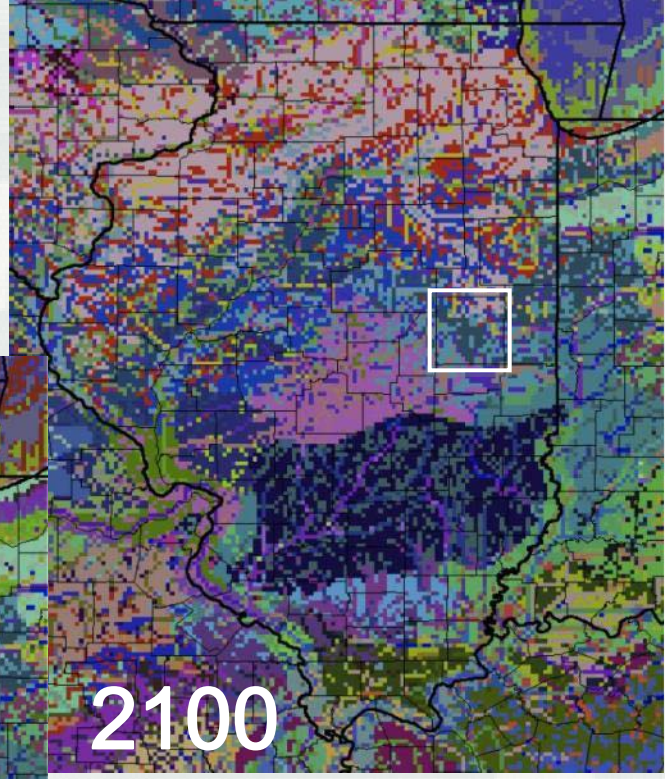
PCM
B1
Scenario

Illinois

Raw
Clusters

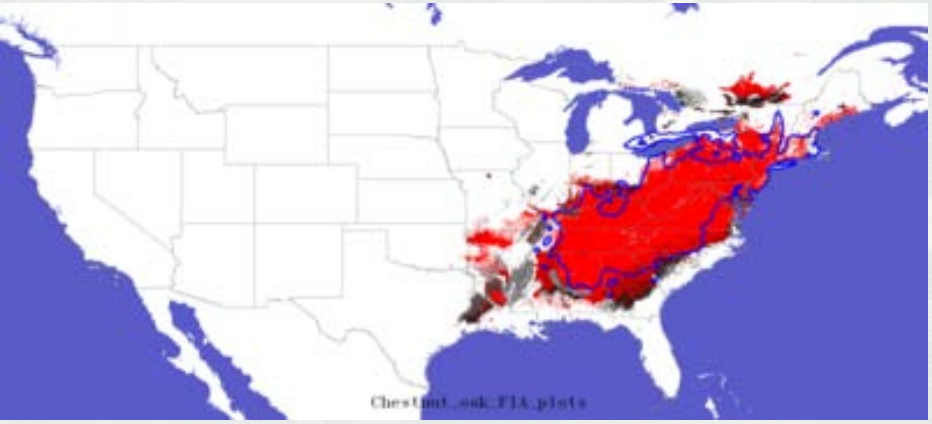






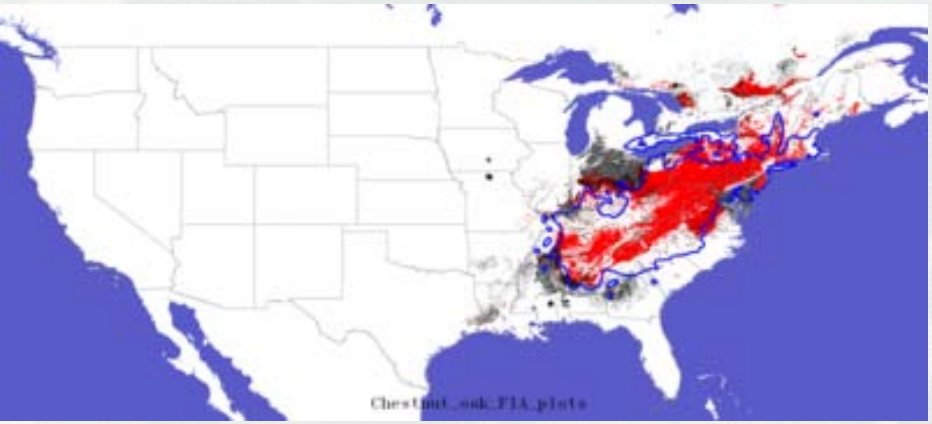
Hadley
B1
Scenario

Forest Service Application



PCM, Scenario A1, 2000-2100 - Chestnut_oak

Hadley, Scenario A1, 2000-2050 - Longleaf_pine



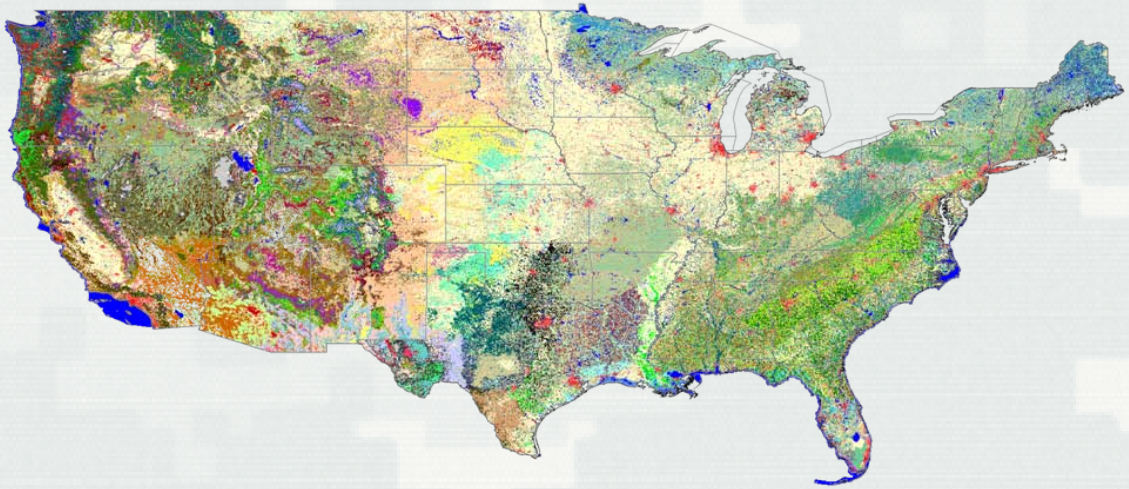
http://www.geobabble.org/~hnw/global/treeranges2/climate_change

Results

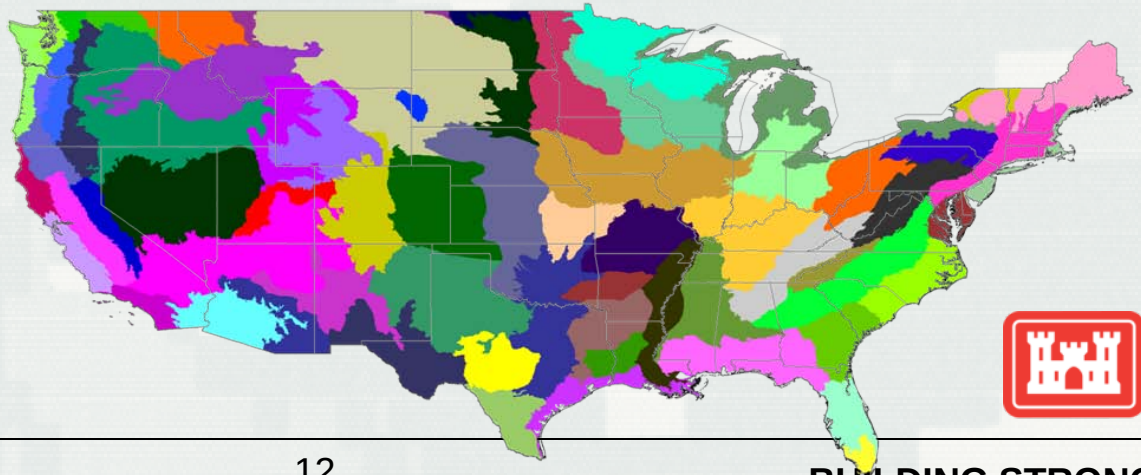
- Correlation with GAP and TNC
- Application of correlation to future
- Sample look at Illinois
- Results for all military installations

Correlate Clusters with Ecosystems

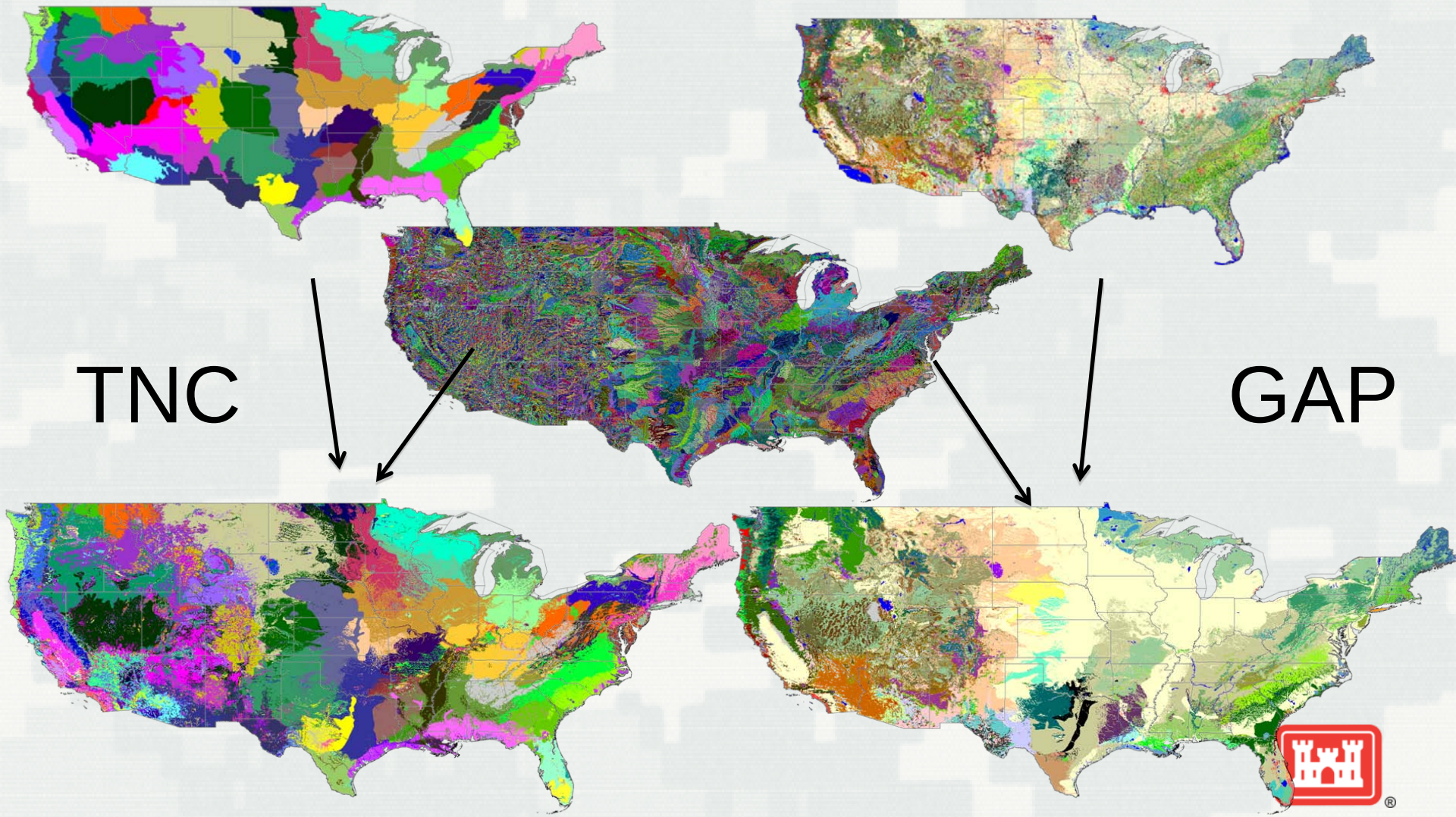
- Begin with ecosystem map
  - ▶ GAP 2010
    - US
    - 533 types



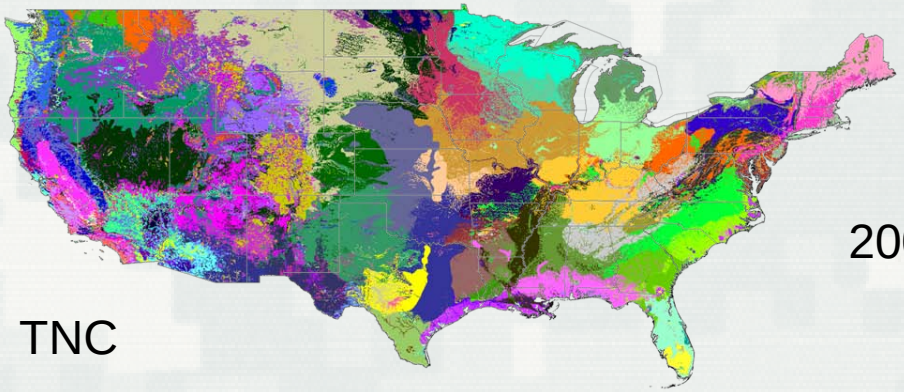
  - ▶ TNC 2010
    - Global
    - 814 types



Correlate Clusters with Ecosystems

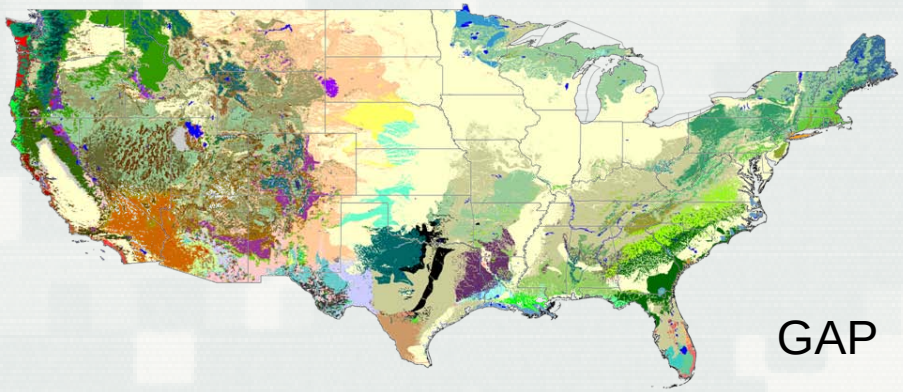


PCM model – B1 scenario (low-low)

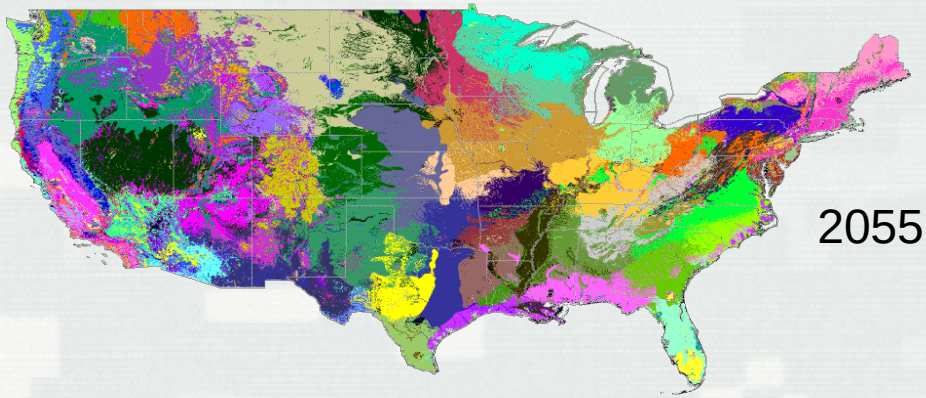


TNC

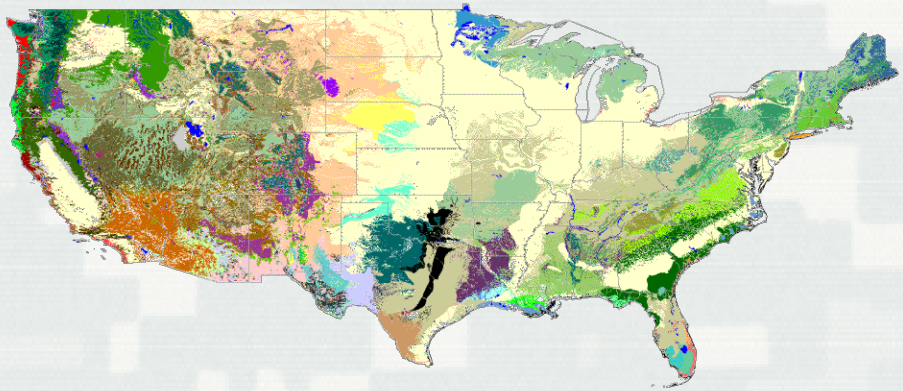
2000

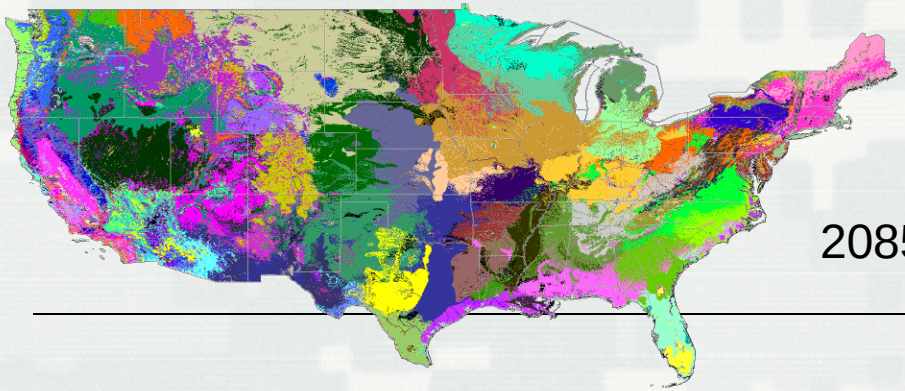


GAP

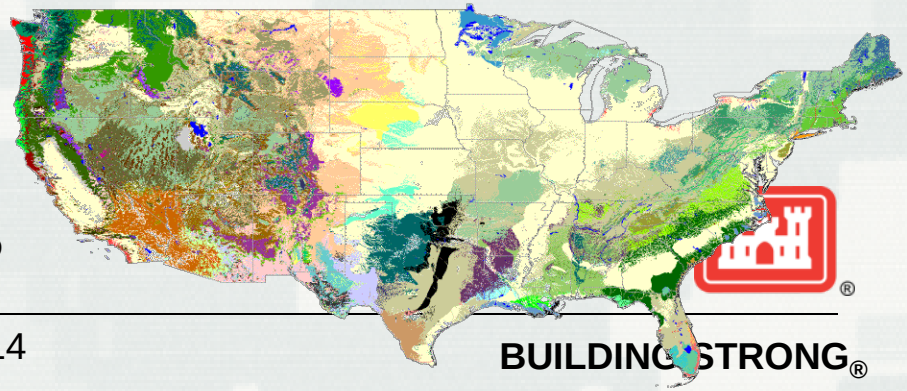


2055

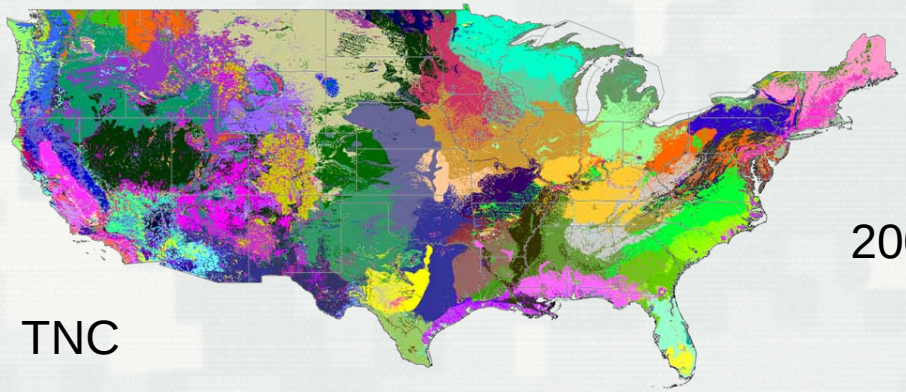




2085

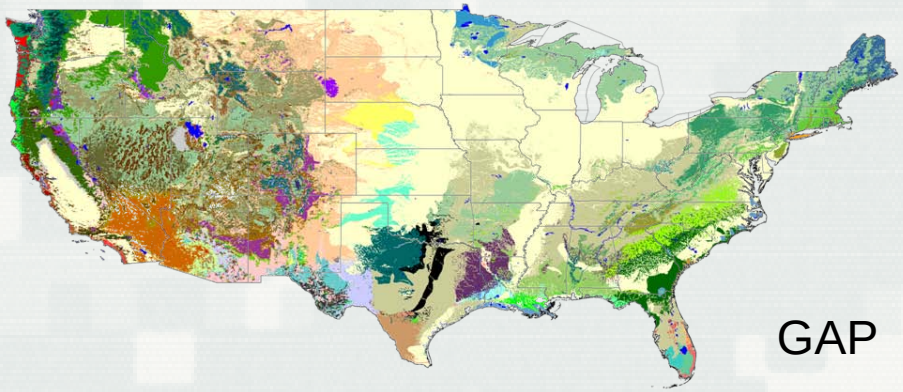


Hadley model – A1 scenario (high-high)

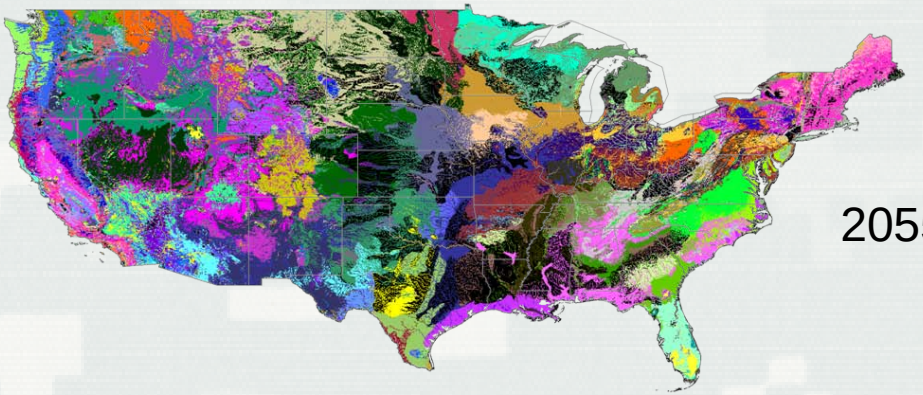


TNC

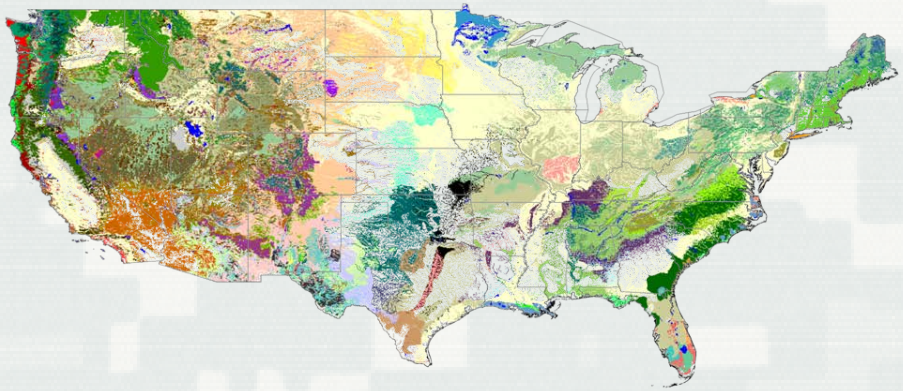
2000

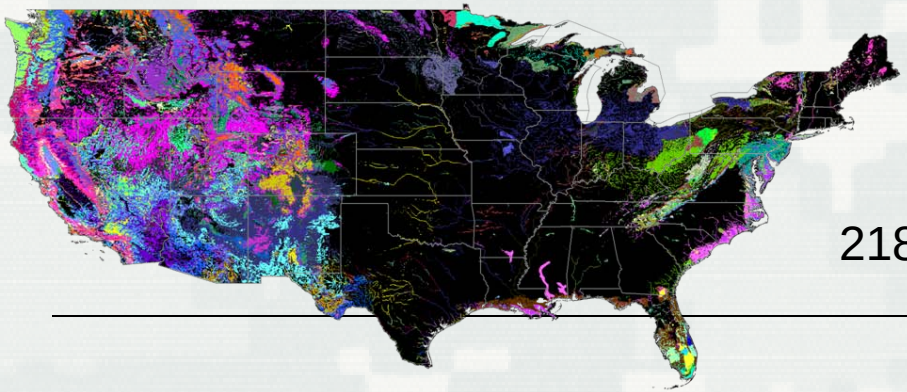


GAP

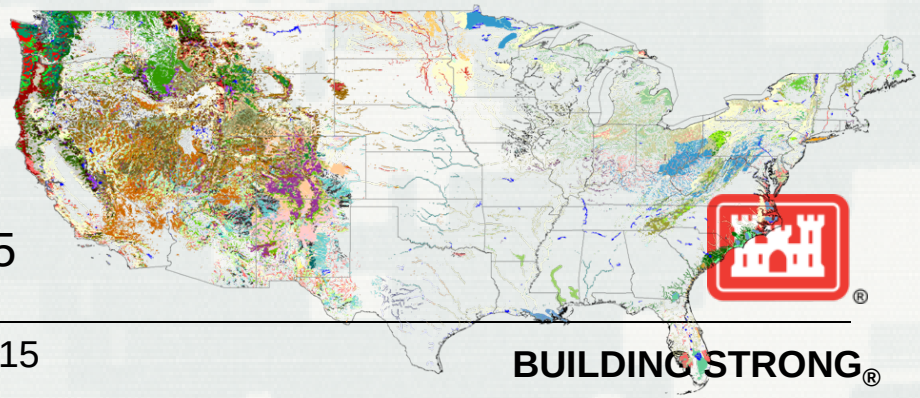


2055

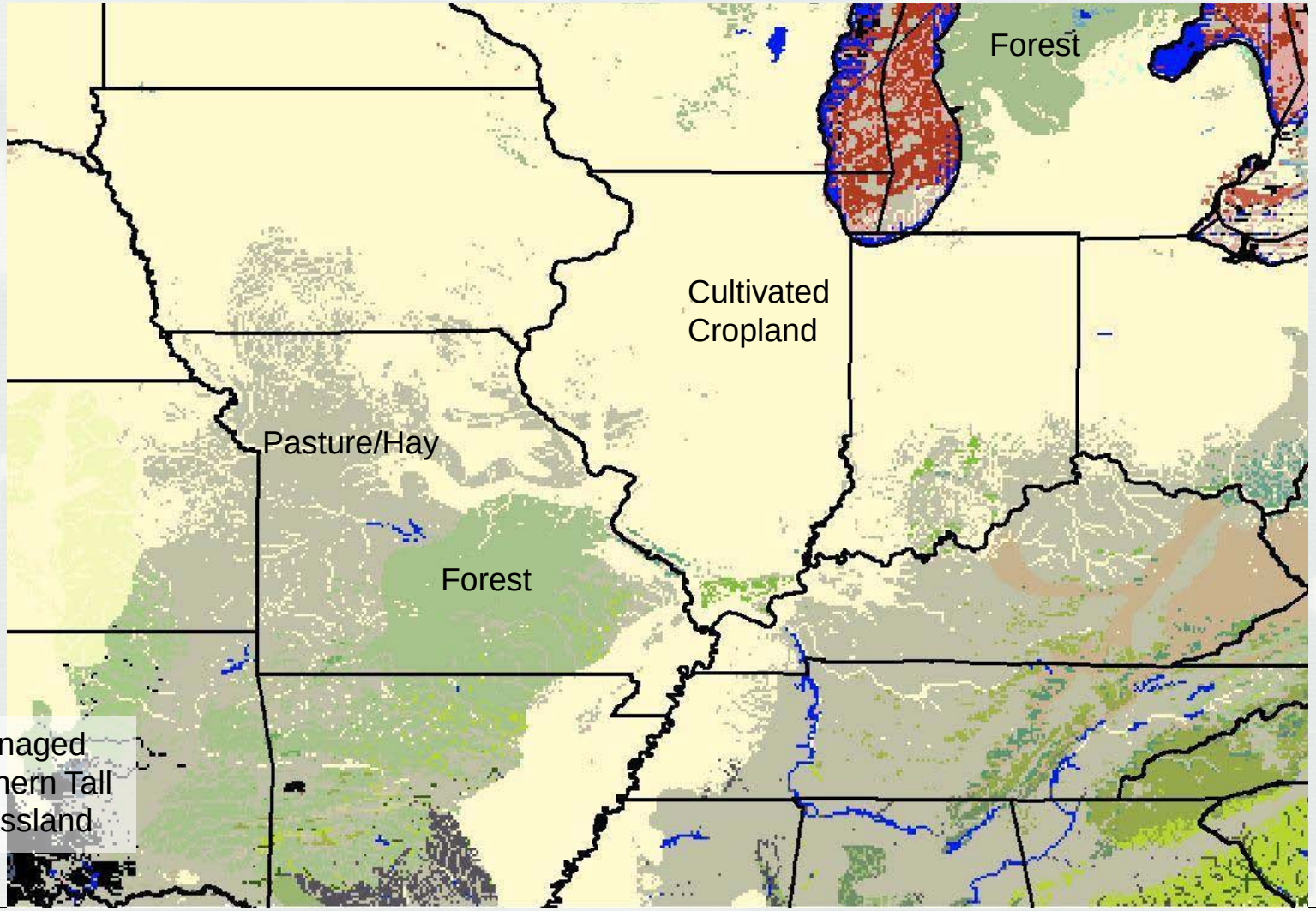




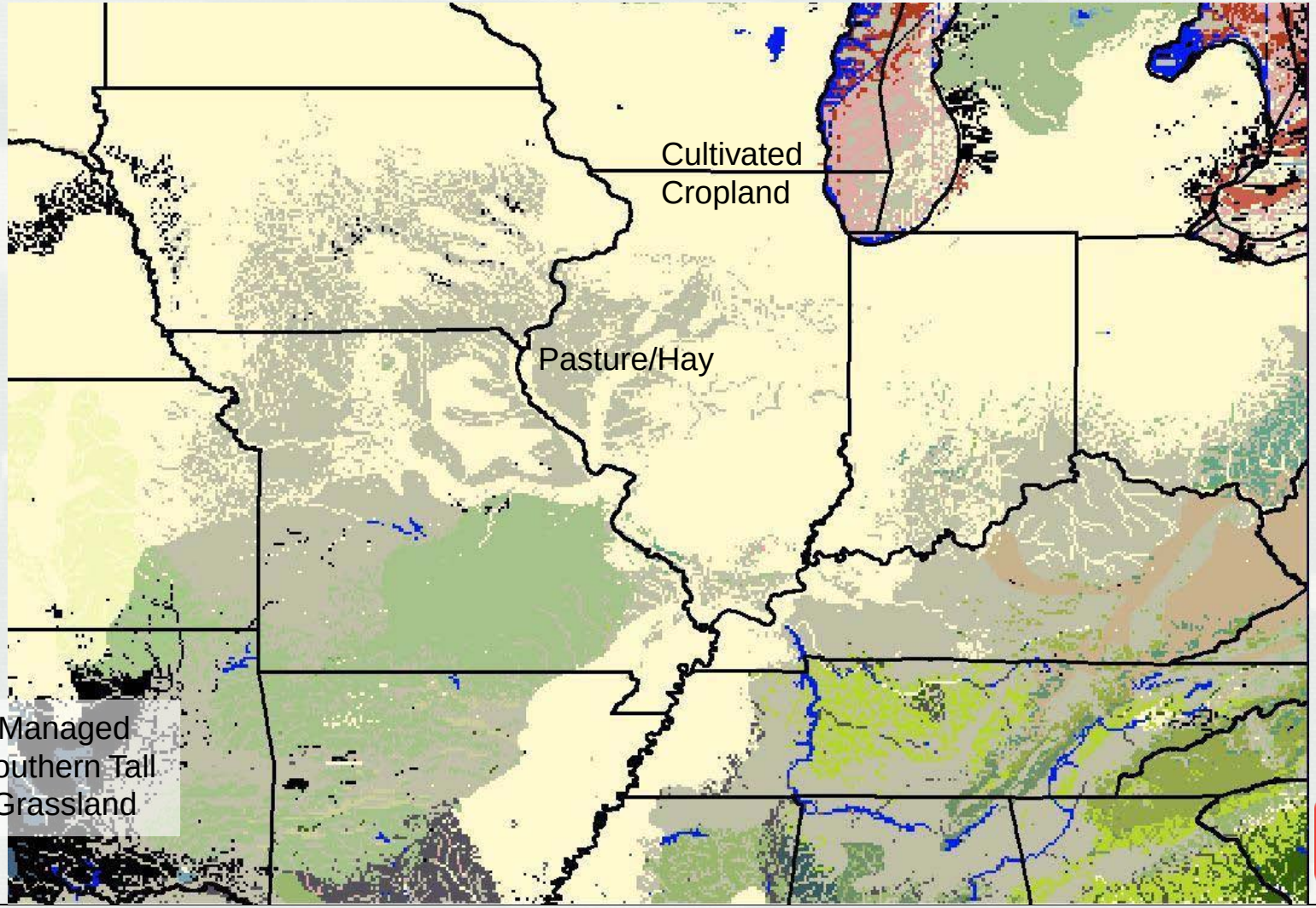
2185



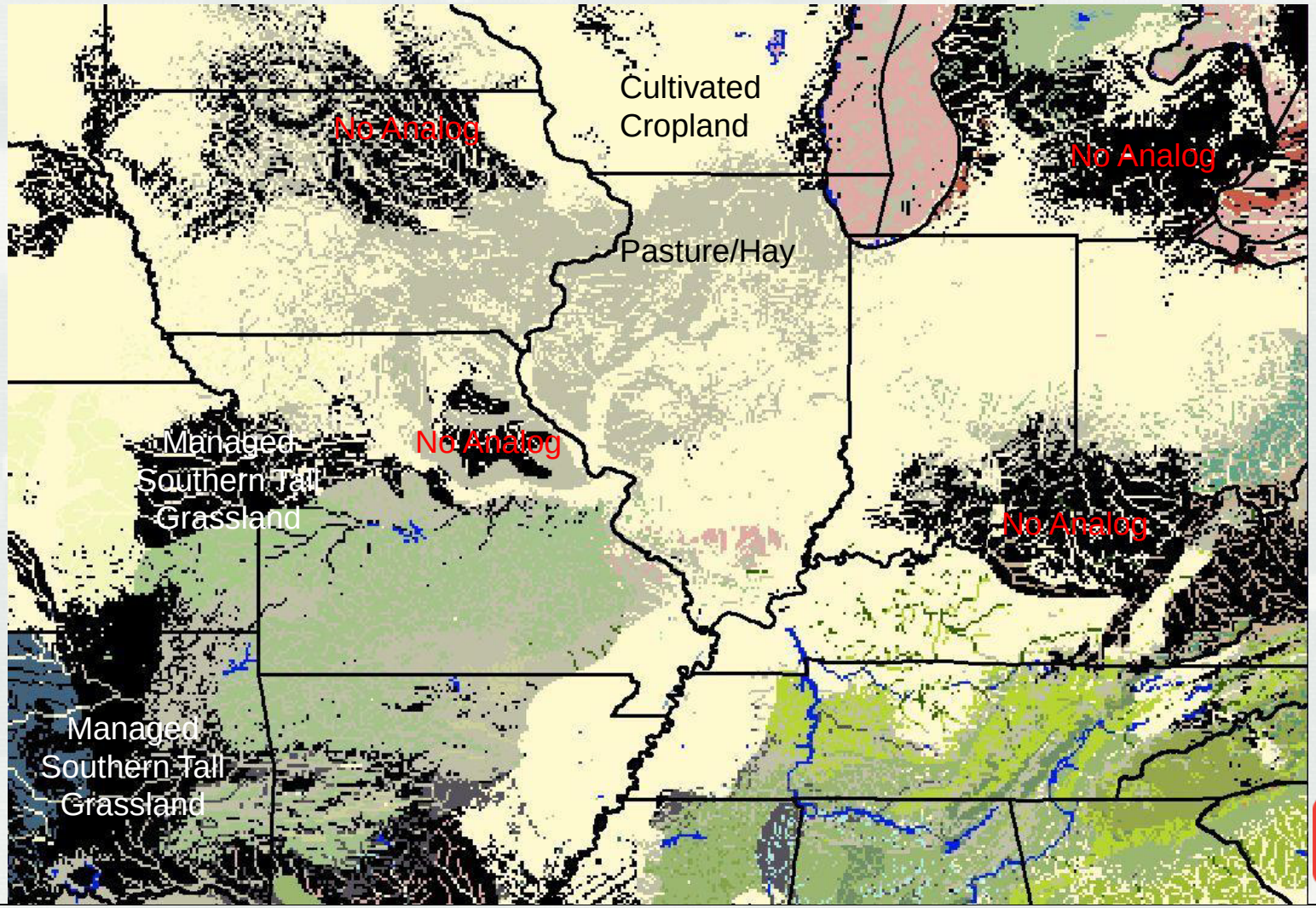
Illinois GAP – Current



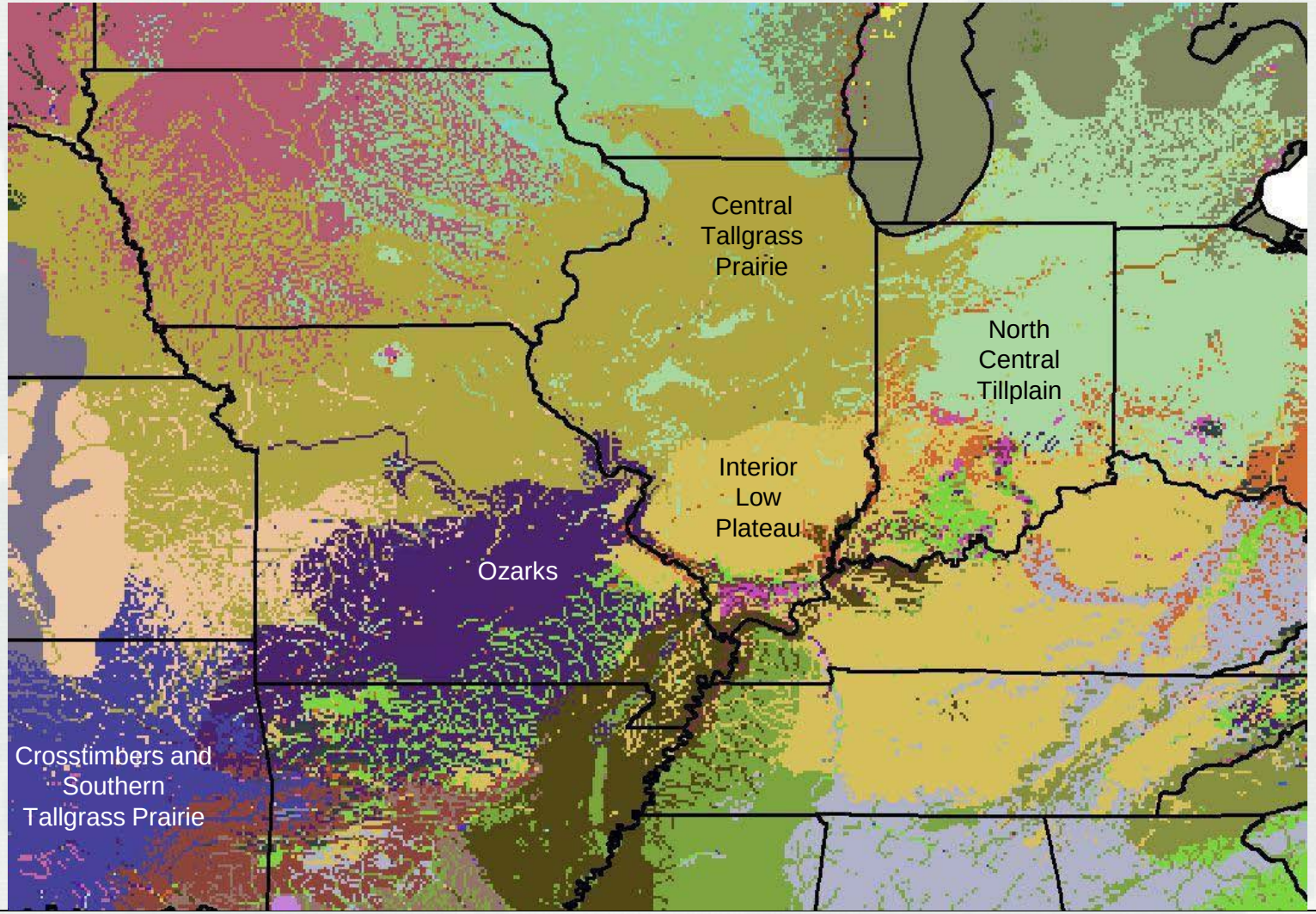
Illinois GAP – PCM A1 2055



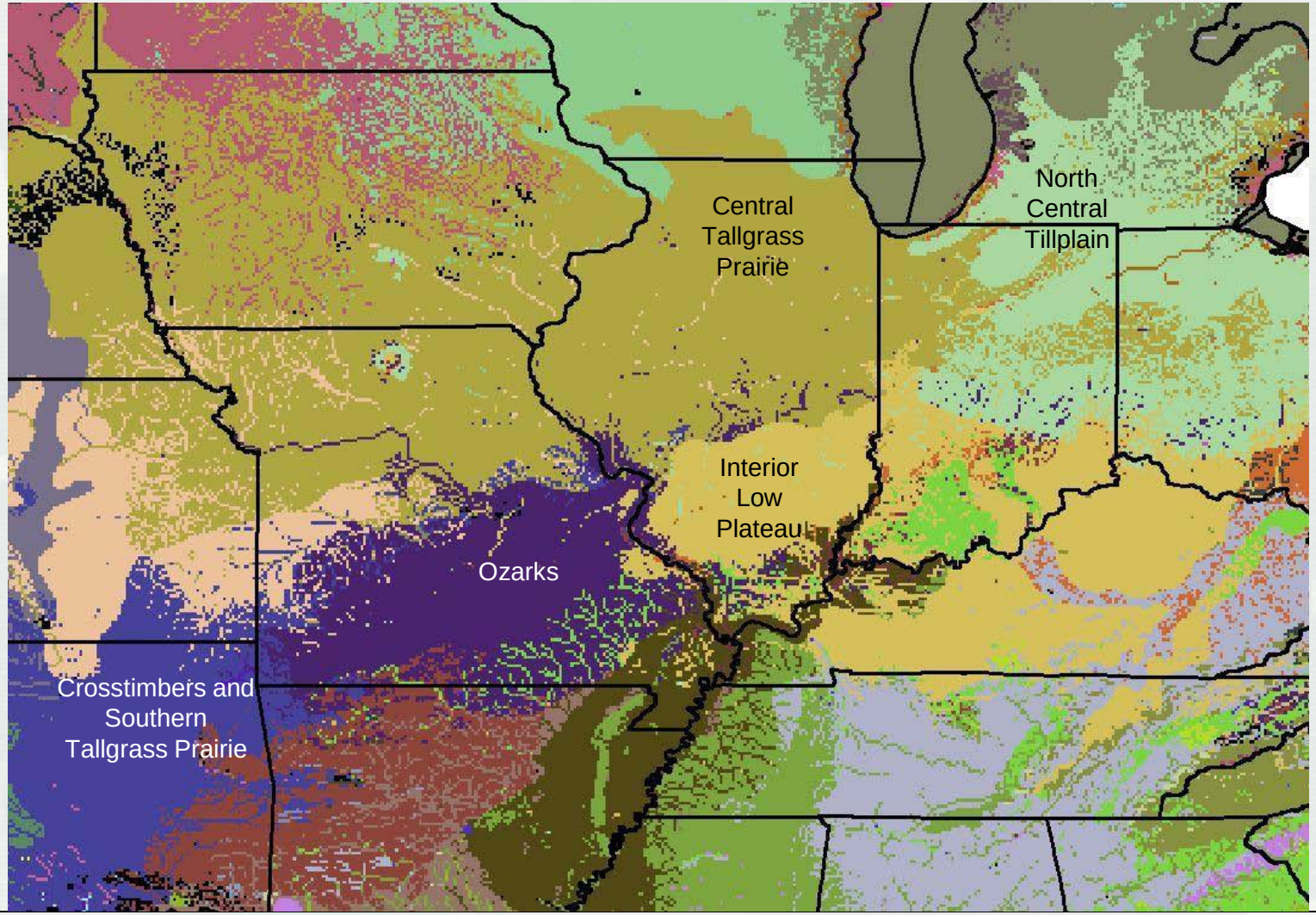
Illinois GAP – PCM A1 2085



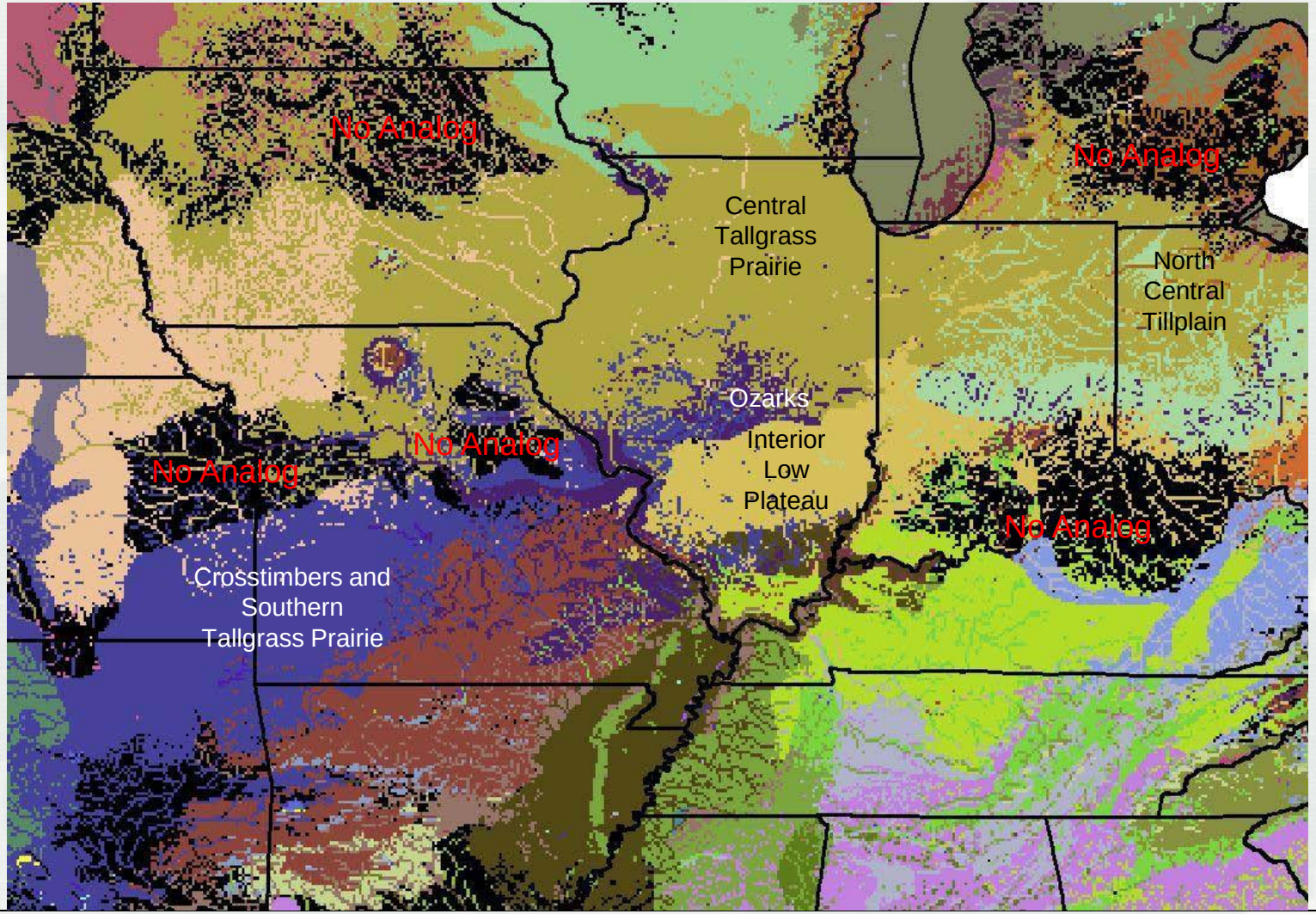
Illinois TNC – Current



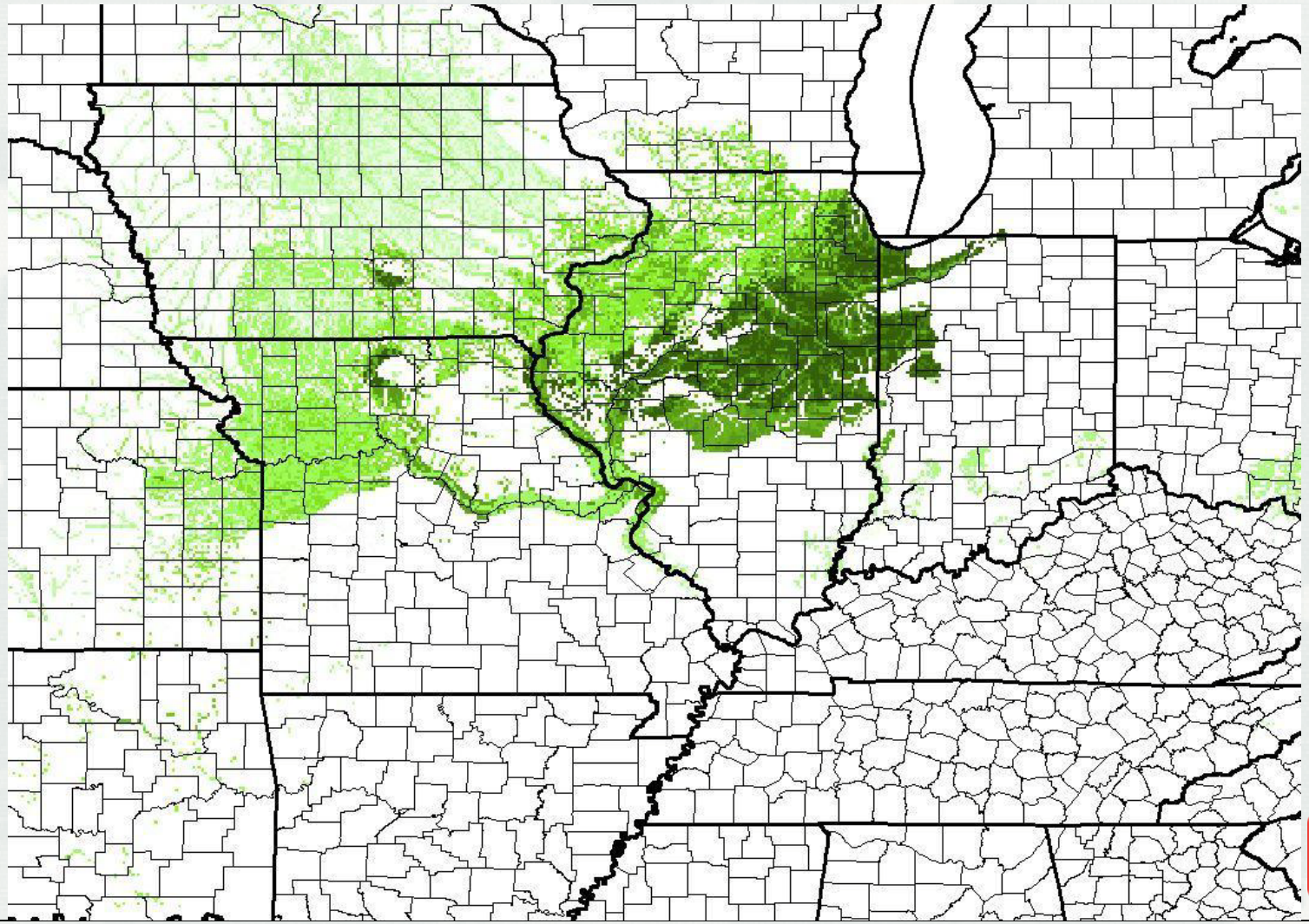
Illinois TNC – PCM A1 2055



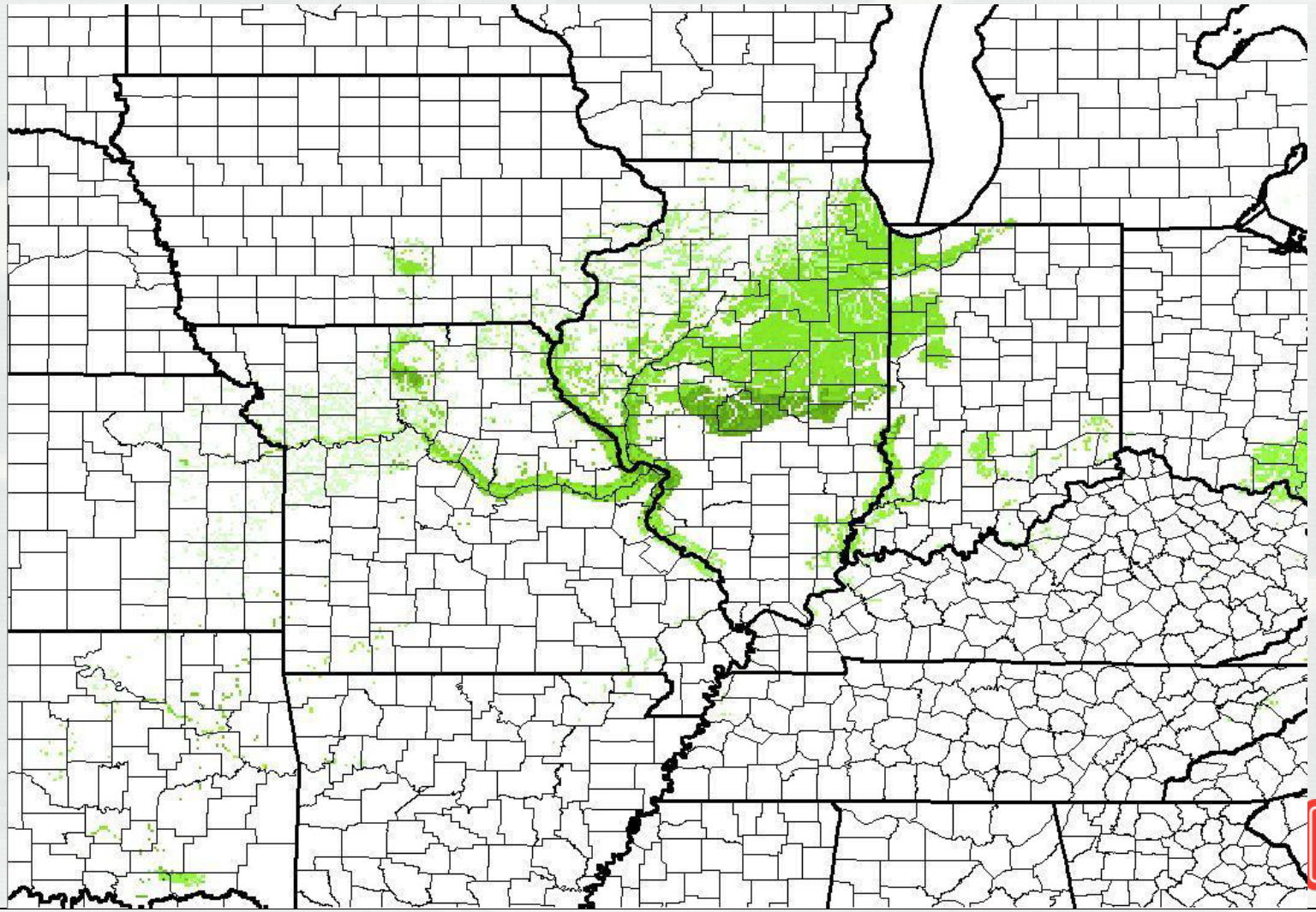
Illinois TNC – PCM A1 2085



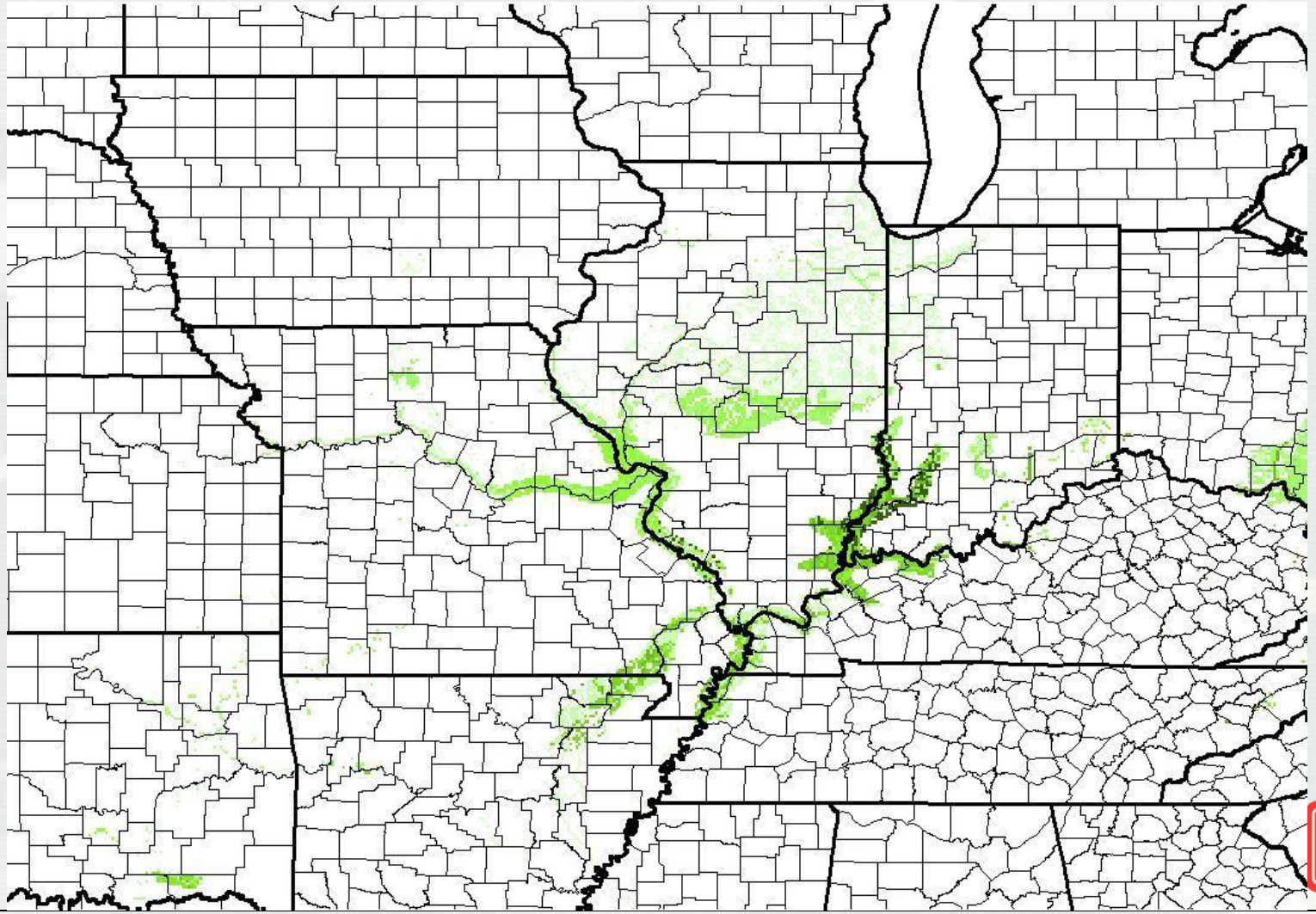
East-Cent Ill – Similar – Current



East-Cent Ill – HAD B1 2055



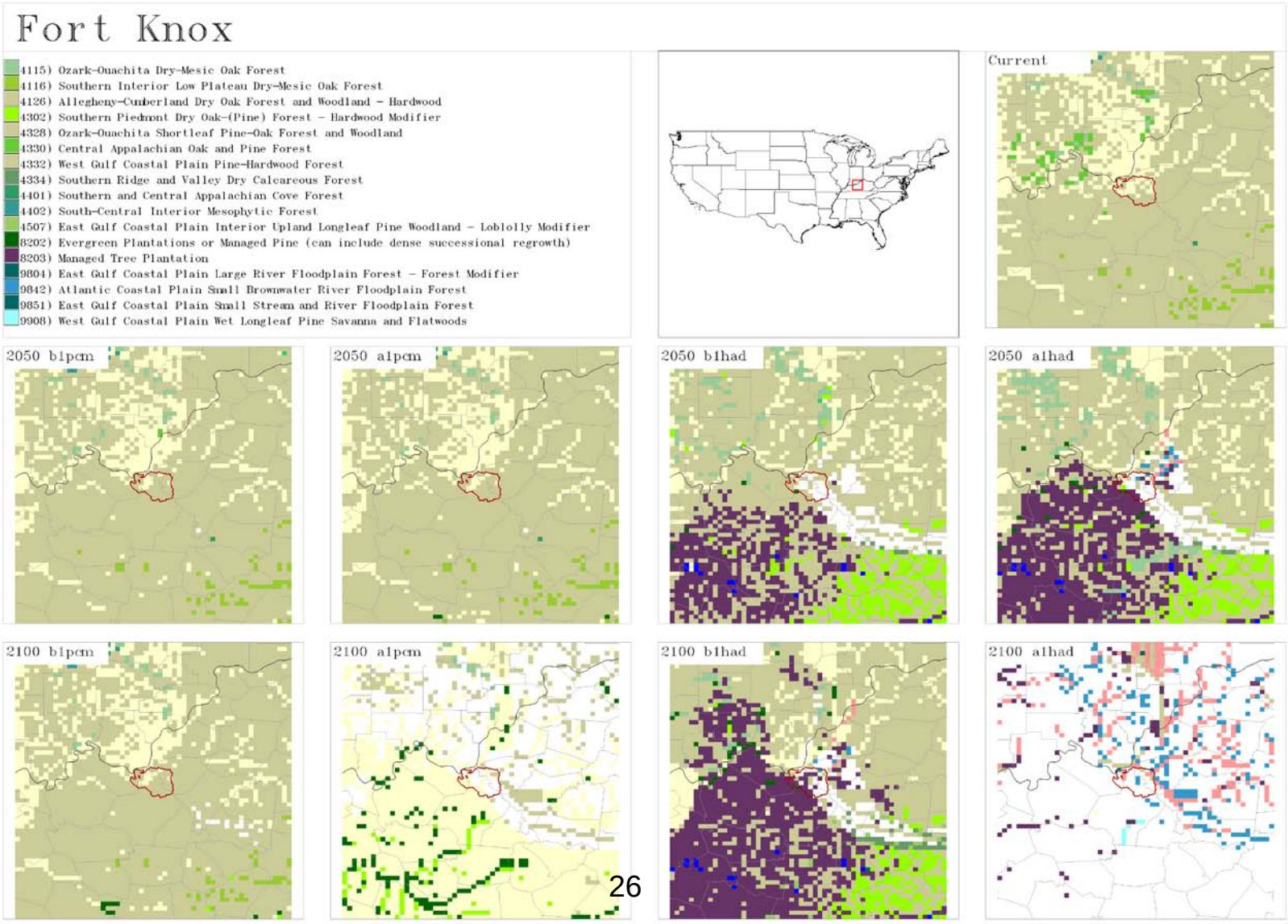
East-Cent Ill – HAD B1 2085



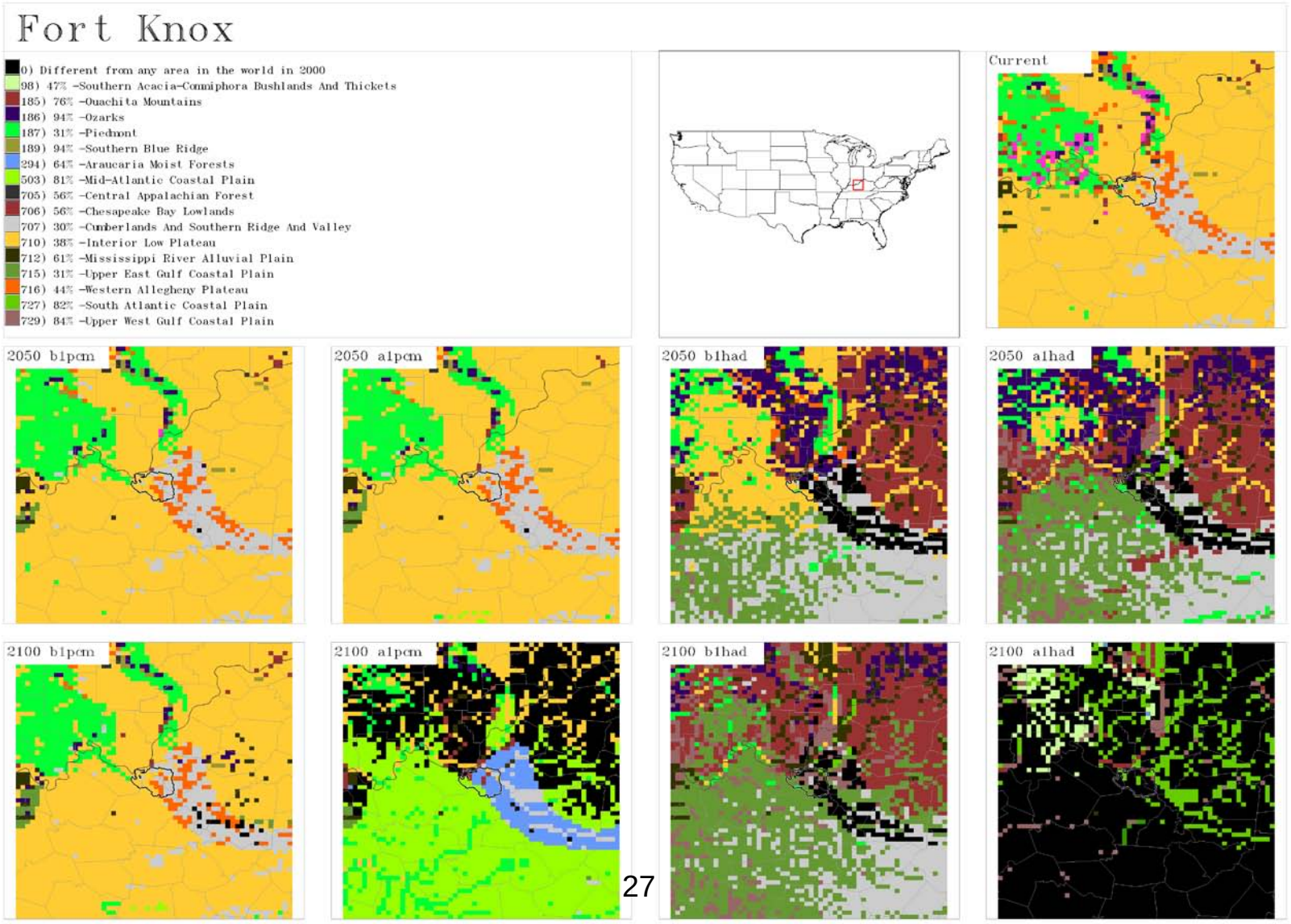
Results for Military Installations

- All Navy, Marines, Air Force, and Army
- Two Models
  - Hadley and PCM
- Two Scenarios
  - A1 and B1
- Three times
  - 2000, 2050, and 2080

Sample GAP – Fort Knox



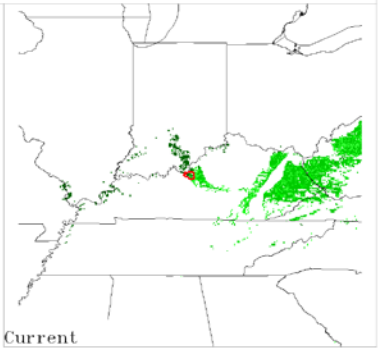
Sample TNC – Fort Knox

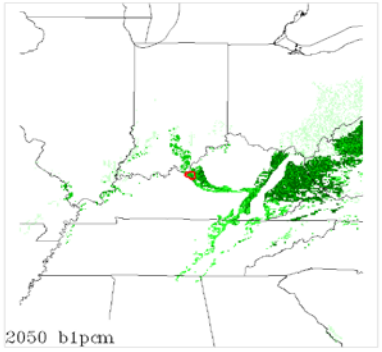


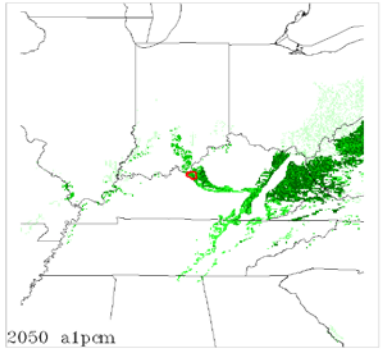
Sample Similar – Fort Knox

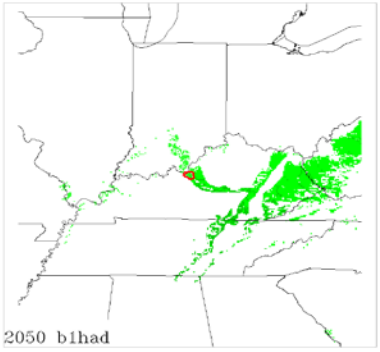
Fort Knox

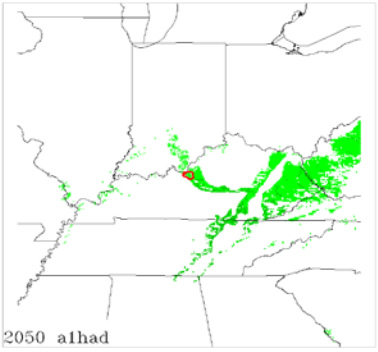
These images show where the forecasted physical and climate conditions most closely match the conditions found across the region in 2000. This answers the question, "Where can I go today to find the forecasted conditions for this installation?"

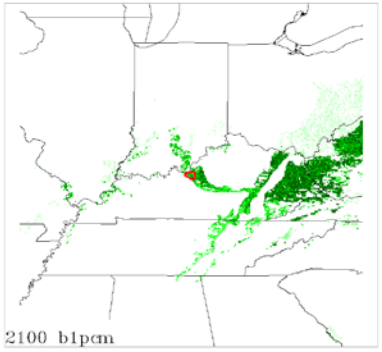


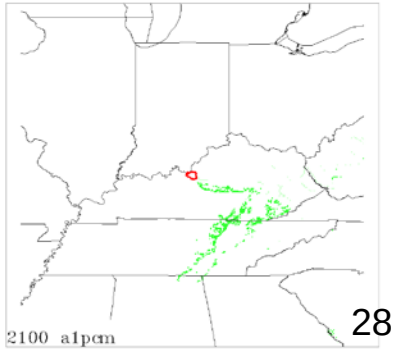


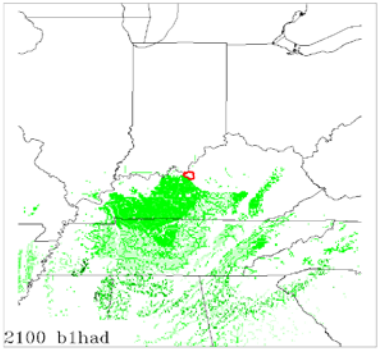


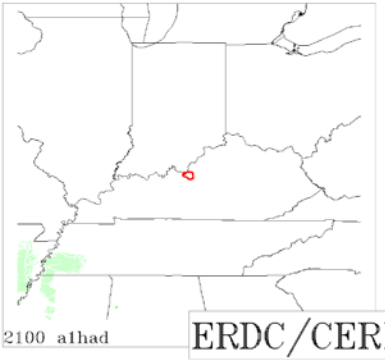












ERDC/CERL

Discussion

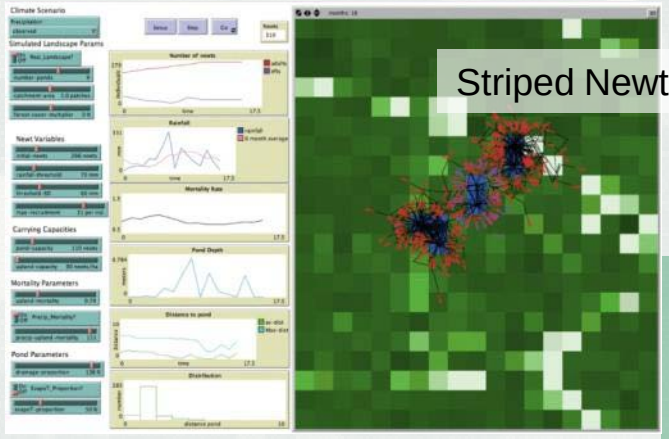
- We have a process for turning GCM/RCM forecasts into potential future ecosystem maps.
- We applied the process to the last round of forecasts
- Ready to apply to the next round
- Massive ecosystem shifts?

Next?

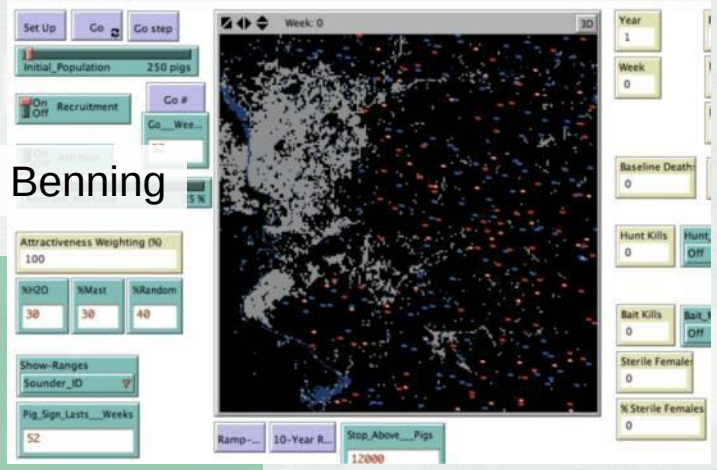
Two parts:

- Forecasted conditions currently support what ecosystems? ✔
- How and when will current ecosystems shift in response?
  - Resilience
  - Persistence
  - Seed distribution rates
  - ??

Some Ecological Sim Models

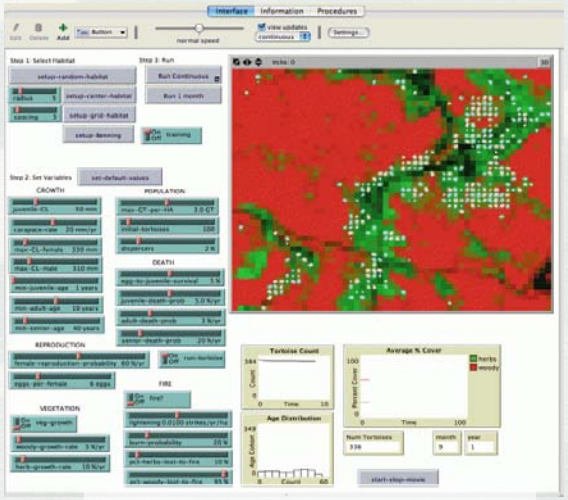


Striped Newt, Ft. Stewart

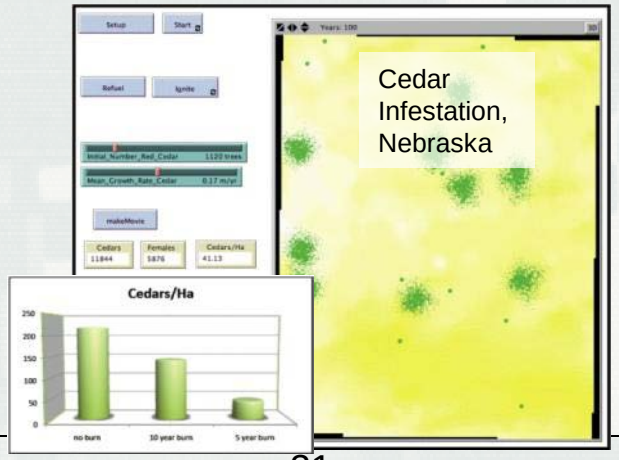


Feral Hogs, Fort Benning

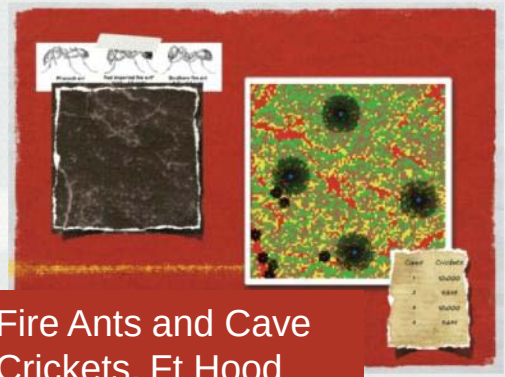
- Quick
- Spatial
- Agent-based



Gopher Tortoise, Ft. Benning



Cedar Infestation, Nebraska



Fire Ants and Cave Crickets, Ft Hood

Questions??

- Sample Forest Service forecasts of movement of optimal tree habitat:
  - http://www.geobabble.org/~hnw/global/treeranges/climate_change2

- ERDC-CERL forecasts of ecosystem shifts around military installations:
  - ►http://earth.cecer.army.mil